Rocky Flats Environmental Technology Site: Actinide Migration Evaluation
Meetings February 2-4, 2004
Advisory Group Greg Choppin, David Clark, David Janecky, Leonard Lane

Summary and Recommendations for Path Forward

As contract completion draws closer it will be more important to make the best decisions and implement them to avoid re-doing work and raising questions as to the technical basis of the decisions and actions taken Accomplishing these goals requires utilizing Site databases, modeling results, expertise, and documenting these in plans and reports Building 444, pond reconfiguration evaluation, and long-term monitoring are key areas for attention at this time Understanding and documenting uncertainty and its implication in remediation activities (such as in the kriging analyses used to define the "Dig/No Dig" line in the 903 Lip Area) remains a critical factor in achieving surface water quality protection As contaminant source areas are remediated to required standards and criteria (e g RSAL's) it is important to document the rational for inclusion/exclusion of "out of source are" hot spots Comprehensive evaluations and decisions regarding remediations and reconfigurations often include selecting an action from a suite of alternatives (*e g* pond reconfiguration study) We recommend that the path forward in selecting the best alternative remediation/management plan from among alternatives should continue to emphasize a multi-objective approach that involves peer review and stakeholder participation, and public review We recommend that application of these techniques be continued and documented in plans and reports

Progress and Integration

The AME Advisors were pleased to see the increased level of progress in integrating databases, modeling, Site personnel expertise and knowledge, in analysis of remediation/site configuration projects and proposed alternatives Furthermore, the Advisors are pleased to see the "value" being added to these analyses, decision processes, and remediation activities by adoption of adaptive management techniques (*e g* 903 Pad dust suppression and tenting, lip area erosion control by installation of erosion control blankets) and by adoption of multi-objective analyses and decisions (e g Walnut Creek Pond reconfiguration)

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Results and Discussions

Building 444 basement – free release question

Frank Gibbs and his team gave us a description of Building 444 issues and D&D The building was used predominantly for depleted uranium and beryllium processing Building spaces include a basement, main floor, mezzanine, and elevator piston shaft The basement area is of primary focus for contamination removal operations and residuals for fixed and removable uranium The information available and approach was discussed, within the context of Be building contamination and volatile organic compound (VOC) contamination plumes The VOC evaluation in the groundwater model provides insight into potential plume flow directions to the southeast across the building site, which could intersect the building basement structure and residual contamination The Advisors requested information on background natural uranium concentrations in the concrete Secondly, uranium from background and contamination in samples of sump waters is of interest for evaluation of existing mobility, which has been documented to be relatively limited at other areas of the Site Data do exist for low levels of uranium contamination in seeps along the Woman Creek drainage below this building area Given consistent results from this area and building, the Advisors are confident that limiting D&D operations to enhance worker safety can be achieved with substantial protection against future contamination from mobility of the uranium from Building 444

Groundwater Modeling

Chris Dayton gave a brief report on the groundwater work The principle foci are the transport paths for VOC contamination and how the contaminant plumes may intersect and affect its migration The ground water discharge rates were not provided Apparently, these are known and would be useful information in evaluating, especially locally, where there also may be contamination Concentrations of nitrate and of metals and their migration rates are also of importance as this is necessary information for proper, reliable modeling and interpretation of uranium behavior This also is of importance in evaluating B444 plume issues as it affects the groundwater, both surface but, even more, near-surface issues This review confirmed the confidence the AME advisors have in the value of the modeling being done on this issue

900-11 IM/IRA

This presentation by Ian Paton and Jeff Myers focused on the 903 Lip Area soil removal project and the associated decision documents/remedial actions The Advisors were pleased to see the sophistication and depth of the analyses, including 1) geostatistical analyses of the lip extension area to define a 90% confidence line, where statistically, the line defines a spatial region containing the 50 pCi/g contaminated soil with 90% probability Excavations

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within this line should then remove soils contaminated to 50 pCi/g or higher with 90% confidence, 2) Lip Area soil removal-erosion control measures including dust suppression measures and application of soil erosion control blankets within a day of the excavation, 3) internal review of IM/IRA documents, and 4) regulator and public review in February 2004

The geostatistical analyses were well done and represent appropriate application of advanced analyses techniques to spatially distributed soil sample concentration data The Advisors were concerned about the lack of uncertainty analyses of the contamination concentration data in defining the boundary of relatively contiguous contamination -- the definition of extent of removal by the 90% confidence line as a "Dig/No Dig" line Outside of the contiguous contamination area as defined by the kriging analyses, there needs to be a clear definition of decision approach and criteria for "hot spots" of contamination Alternate approaches and coverage can enhance protection of surface water quality, while limiting disturbance of soils and existing ecologic communities But, the decision to remediate or leave a hot spot in place should be technically well defined and documented

The Lip Area soil removal accompanied by dust suppression and followed immediately (within a day) by intensive erosion control measures (application of dense erosion control blankets) represent significant environmental protection steps and demonstrate that lessons learned from previous wind and water erosion – plutonium (Pu) transport events have resulted in adaptation of remediation/management actions This adaptive remediation-environmental protection process from documented planning through implementation should serve as a "model" for ongoing and future environmental remediation and IM/IRA activities at RFETS and elsewhere

Finally, the Advisors were also pleased to see the internal, regulator, and public review processes being undertaken as part of the 900-11 IM/IRA documentation and implementation process

903 Pad and Inner Lip Area status & Tour

Lane Butler and Mike Keating presented an update on the status of remediation of the 903 Pad and Lip Area followed by a short visit to the 903 Lip Area led by Mike Keating and Ian Paton Remediation of the 903 Pad was completed on December 4, 2003 The Advisors were pleased to hear about the successful dust suppression/wind erosion prevention measures taken via soil wetting/sprinkling during operations and the use of a "tent" to protect the exposed soil from wind erosion during excavation and removal of contaminated soil As stated earlier, these measures represent significant improvements in concurrent remediation - environmental protection over previous remediation activities at the 903 Pad The short tour to the 903 Lip Area helped the Advisors appreciate remediation operation, the appearance and density of the erosion control blankets, and the opportunity for quickly re-establishing vegetative cover of the site

Original Process Waste Lines characterization

Gary Carnival described continuing characterization and removal or stabilization of the OPWL system (piping and valve vaults) He also described exploration of possibilities for associated contamination Little contamination has been found and, where it has been found, distribution is limited, primarily associated with valve vaults and in the fill above the piping The Advisors are very pleased that the results are consistent with the behavior of Pu documented previously for surface water, soils, and ecological systems This characterization also further supports the results of under-building contamination samples

RFETS transition to legacy management

Scott Surovchak, DOE-RFFO, met with the AME Advisors to discuss transition to legacy management and his new assignment to the project Mr Surovchak presented a broad overview of his assignment and stressed the breadth of his duties and the need to carefully specify and document the scope of the transition to legacy management at RFETS The AME advisors briefly discussed their thoughts on the topic and pointed out that we had prepared a document entitled "A Transition to Stewardship at Rocky Flats, Summary Document" (Draft 2 0, June 3, 2003), and Mr Surovchak noted that he had received a copy of this document Additional discussions served to put the environmental aspects of the transition to legacy management in perspective with respect to human resources (retirement funds, etc), documents, information technology, and other factors The Advisors, while focusing on the environmental aspects and remaining vulnerabilities (both for short and long-term), appreciate learning about the scope of transition activities in other areas

Walnut Creek pond reconfiguration

Ian Paton, AME Group, presented results of analyses of six pond reconfiguration alternatives on north and South Walnut Creek (the A and B series ponds) The Advisors were pleased to see an evolution in the sophistication and breadth of the analysis tools and interpretations being used in these analyses In addition to the historical databases and modeling information, multi-objective, or multi-criterion, analyses were performed including criteria for water quality, habitat, wetlands, dam safety/maintenance, capital costs, operating costs, and community acceptance A new and unique (with respect to AME and RFETS) application of decision theory was also used in ranking the six alternatives using individual scores and weighting factors for each criteria The weighted scores were then summed to give each alternative an overall score This method is powerful in that it is transparent, repeatable, and easy to communicate to cooperators, stakeholders, and the public Its weaknesses include the subjectivity in selecting the weights for each evaluation criteria (i e water quality,

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habitat, etc) However, this weakness can be mostly overcome by involving stakeholders in discussing and selecting the weights, varying the weights to determine the sensitivity of the alternative ranking to selection of the weighting values, and via peer review to include additional scientific input

The results of the multi-objective analyses and decision theory is that Alternative 4 (Dams and ponds remain as they are) and Alternative 5 (Keep Pond A3, terminal ponds, and modify interior ponds to low head or breach) were ranked highest and thus recommended as the preferred alternatives The Advisors recommend continuation of discussion and analyses of water routing and interior pond cleanout An RSAL level or the lowest achievable level of contamination need to be evaluated, and that the multi-objective analysis–decision theory approach should continue to be applied to gain the advantages described above

The Role of Colloids in Actinide Migration at RFETS

Introduction – A dominant, and often controlling feature of Pu and americium (Am) geochemistry is their very low solubility in natural waters, and their strong tendency to adsorb to soil and mineral surfaces Based on these geochemical characteristics, one might conclude that plutonium and americium would adhere to the geological matrix, and remain immobile in the environment Yet, there have been a growing number of field studies documenting movement of low concentrations of these low-solubility radionuclides in surface and ground waters [1-3] One explanation that has gained scientific support is that small concentrations of low-solubility radionuclides, such as Pu and Am can be transported in surface or groundwater through the association with naturally occurring particulates whose small size (1 nm – 1 μm)[4] affords the ability to remain suspended and therefore transported in natural aquatic systems Although the idea that colloids may be a transport mechanism for contaminants in groundwater is not new, compelling field evidence has previously been lacking In recent times, new scientific techniques have provided better insights into the physicochemical nature of colloid and particulate transport, and the concept of colloid-facilitated transport has gained broad acceptance

What are Colloids and How are they Involved in Actinide Transport? Colloids are small, naturally occurring particulates that are ubiquitous in groundwater, and composed of inorganic minerals or organic species These natural colloids originate from the mechanical weathering of rocks, plants, and soil [5] In surface and shallow ground waters, colloids of organic matter are fairly common, while deep waters in fractured rock is generally dominated by colloids of inorganic materials that are reflective of the local mineralogy [5] Colloids can be involved in contaminant transport if those contaminants strongly associate with the colloids, and the colloids themselves minimally interact with the stationary phase Low solubility contaminants like Pu and Am are likely candidates for colloidal transport, and the radionuclide/colloid combination is often referred to as a pseudocolloid

In addition to association with inorganic and organic colloids, Pu(IV) and Am(III) ions are prone to undergo polymerization reactions under environmental conditions to form colloidal polymers, and these are often referred to as intrinsic colloids Intrinsic colloids can form when the concentration of the actinide ions in solution exceeds the solubility product for the formation of a solid phase, which is dependent on both the oxidation state of the ion and the composition of the groundwater The intrinsic colloid of Pu(IV) is easily produced and can remain stable in near neutral solutions [6] The Pu(IV) colloidal concentrations of natural waters often exceeds the dissolved Pu(IV) species by several orders of magnitude

A variety of studies have shown that colloidal particles are found in all natural waters, and show a wide range in concentration depending on local geochemistry Measured values range from 0 0002 to 200 mg/L, but difficulties in sampling and analysis make accurate concentrations difficult and measured values most likely represent a maximum [5] The amount of contamination available, concentration and composition of the colloids, and local hydrologic conditions of the environment are all important factors in determining how much contamination can be transported via colloids

A combination of recent field and laboratory studies highlight the importance of the specific local geologic, geochemical, and hydrological conditions in determining if colloids will or will not facilitate the transport of low-solubility radionuclides Ryan and Elimelech (1996) have outlined three conditions that must be met in order for colloid transport to occur [7] First, colloids must be present, second, contaminants must be associated with the colloids, and third, the colloid-contaminant combination must be mobile in the environment

The Role of Colloids at RFETS – At RFETS, Pu and Am contamination has occurred in the shallow subsurface composed of alluvium (Figure 1) Water at RFETS and the surrounding area moves as surface water, shallow groundwater, and deep groundwater [8] Surface water generally flows west to east Shallow groundwater refers to water within the alluvium and weathered bedrock geologic units and is found to a depth of 30 meters Surface water and shallow groundwater are inextricably linked Water from stream channels infiltrates downward, recharging the shallow groundwater Beneath the alluvium is a highly, impermeable bedrock that inhibits vertical flow As a result, shallow groundwater flows laterally where it either discharges as baseflow into the streams or into valley-fill alluvium material Approximately 200-300 meters below the surface lies the Fox Hills Sandstone, where, isolated from the surface and shallow groundwater, the deep regional groundwater flows The deep groundwater is not a pathway for actinide contaminants because of its isolation from the surface and shallow groundwater [9]

Several field studies were undertaken at RFETS to assess the ability of colloids and particulates to transport Pu and Am in the surface and shallow groundwater Surface water samples were collected from storm runoff and pond discharge between 1998 and 2000 [3] The collected water contained low levels of Pu and Am Results showed that greater than 90 percent of the Pu and Am was

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detected in the particulate and colloidal fractions of the groundwater Isoelectric experiments showed the Pu was associated with the organic component of the colloids The low levels of Pu and Am in surface water at RFETS are transported by the colloidal and particulate fraction and not the dissolved fraction of the water

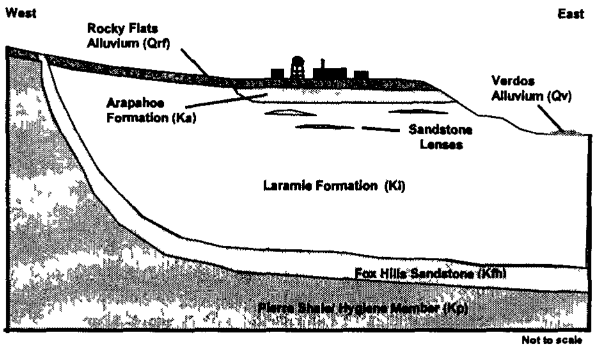

Figure 1 Schematic cross-section of RFETS, west to east Regional Fox Hills Sandstone (regional aquifer) is 200-300 meters below the ground surface and isolated from shallow ground water by the impermeable claystone of the Laramie Formation

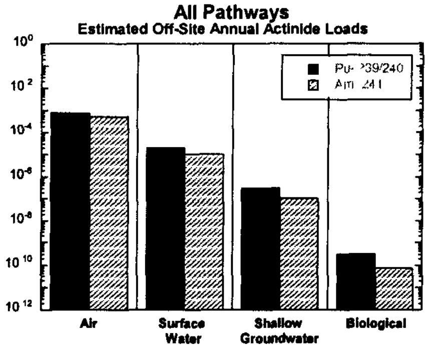

Figure 2 Comparison of the quantitative estimates of off-site actinide loads (Ci/yr) from the air, surface water, shallow groundwater and biological pathways Note log scale After Kaiser-Hill, (2002)

In an earlier field study conducted in 1984, shallow groundwater from a single well was filtered, and analyzed for radionuclides[10] Low levels of Pu were associated with the particulate and colloidal fractions Colloid concentrations were low (<1 mg/L) and consisted predominantly of clays This study documents that Pu is associated with the colloidal fraction of the groundwater, yet, the low concentration of colloids observed limits the ability of colloids to transport significant quantities of Pu or Am Caution must be used when interpreting these data as Pu concentrations were near the detection limit and the potential to contaminate the sample due to sampling or well installation could not be eliminated

In an effort to further evaluate the potential for contaminant transport in the shallow groundwater, a series of shallow wells were drilled, sampled, and analyzed for colloids and radionuclides[8] Special effort was made in the design and sampling of the wells to limit possible down-hole contamination due to surface soil interaction Concentrations of Pu and Am in four shallow groundwater samples were very low but measurable (i e , ≤0 02 pCi/L),[11] consistent with the initial results of Harnish et al , (1984) Although care was taken to prevent surface contaminants from being carried downhole, the possibility cannot be ruled out The concentrations and corresponding colloid loads are low and do not represent a significant source for transport of low-solubility radionuclides

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Field studies at RFETS have demonstrated that particulate- and colloid-facilitated transport of low-solubility radionuclides, such as Pu and Am, is the dominant mechanism for transport in the surface water and shallow groundwater pathways The low concentrations of colloids detected in shallow groundwater wells, limits the amount of Pu and Am that can be transported in this pathway Studies carried out at RFETS have significantly improved our understanding of the *process* by which plutonium and americium are transported, and give confidence to the recent pathway analysis that concludes that wind and surface water erosion are the dominant actinide migration pathways at RFETS[8] (Figure 2) Unlike other geologic environments, deep groundwater at RFETS is effectively isolated from shallow and surface water, preventing a pathway for deep vertical transport of Pu and Am

Summary – Pu and Am migration in the environment can occur because small amounts of these very low-solubility actinides can associate with particles or colloids (pseudocolloids) or are themselves colloid sized polymers (intrinsic colloids) Pseudocolloids are present in nearly all waters and are formed as a result of the weathering of rocks, soil and plant material At RFETS, sedimentation and resuspension of colloids and particulates in both the surface and shallow groundwater represent the dominant processes for very low levels of Pu and Am migration Since colloids are a part of the overall particulate spectrum, the migration of Pu and Am through the agency of colloids at RFETS has already been quantified in the Pathway Analysis Report The Pathway Analysis Report shows that the two dominant pathways for Pu and Am transport are by air and surface water pathways Shallow groundwater and biological transport were found to be only minor migration pathways

References

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2 Kersting, A B et al Migration of plutonium in groundwater at the Nevada Test Site *Nature* **397**, 56-59 (1999)

3 Santschi, P H , Roberts, K & Guo, L The organic nature of colloidal actinides transported in surface water environments *Environ Sci Technol* **36**, 3711-3719 (2002)

4 Stumm, W *Chemistry of the solid-water interface processes at the mineral-water and particle-water interface in natural systems* Wiley, New York, 1992

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7 Ryan, J N & Elimelech, M Colloid mobilzation and transport in groundwater *Colloids and Surfaces A Physicochem and Engin Aspects* **107**, 1-56 (1996)

8 McCarthy, J F & Degueldre, C (eds) *Environmental particles* Lewis Publisher, Boca Raton, Florida, 1993 Kaiser-Hill Actinide migration evaluation pathway analysis summary report *Kaiser-Hill Company*, ER-108 p 30 (2002)

9 Hurr, R T Hydrology of a Nuclear-processing plant site, Rocky Flats *U S Geological Survey*, Open File Report 76-268 (1976)

10 Harnish, R A , McKnight, D M & Ranville, J F Particulate, colloidal, and dissolved-phase associations of plutonium and americium in a water sample from well 1587 at the Rocky Flats Plant, Colorado U S *Geological Survey Water-Resources Investigations*, Report 93-4175 (1984)

11 Santschi, P H & Roberts, K Final Report on phase speciation of Pu and Am for actinide migration studies at the Rocky Flats Environmental Technology Site *Kaiser-Hill*, p 16 (2002)

Long-term monitoring

Chris Dayton presented a Kaiser-Hill-proposed (but not RFCA Party-accepted) long-term, post-closure monitoring plan Basic elements of the plan included the number and location of points of compliance (POC), points of evaluation (POE), and backup monitoring stations These include surface water, upper stratigraphic unit groundwater, and air monitoring stations Weather stations are also included so that precipitation, temperature, and wind will be measured The key monitoring network design criteria and considerations included regulatory compliance (POC's and POE's), surface and subsurface flow pathways after Site reconfiguration, and the need for contaminant source area determination via redundancy (backup) of monitoring sites The Advisors were pleased to see the integration of water balance modeling, erosion modeling, and reconfiguration drainage analyses evident in the long-term monitoring plan Interpretation of the results of these analyses and the land configuration design suggest that the "final" configuration may need some modifications to avoid creation of hillslope seeps and thus the potential for accelerated soil erosion, and unstable channel segments Because of the high level of integration of databases, simulation modeling, Site expertise, and reconfiguration design underlying the long-term monitoring plan, the Advisors recommend that the "final land configuration" be determined through an iterative process with the long-term monitoring plan and the scientific analyses upon which it is based

Discussions of status & issues

In discussions with the AME Advisors, Dave Shelton, stated that he would send the Advisors a copy of a matrix listing all of the factors being considered in the transition to legacy management This should be helpful in documenting the scope of the legacy management issues In discussion of a related topic (Site reconfiguration) related to legacy management through its impact on site performance with respect to protection of surface water quality and through post-closure maintenance needs, Mr Shelton expressed concerns about the effects of channel re-configurations and their impacts Concerns were that removal of currently stable in-channel structures might have the potential to remobilize stored contaminants and impact wetlands, and that these factors should be considered in the analysis of channel reconfigurations

Documents Provided to Advisory Group

Agenda
Conceptual diagram of alternative IHSS group 900-11 area IM/IRA
Outline for presentation to be presented at Waste Management '04 in March
Paper for Waste Management '04 Conference – "Development of an independent scientific advisory committee to support the closure of Rocky Flats" by C S Dayton and I B Paton
Figures from Walnut Creek – Pond Configuration Alternatives
Denver Post article (February 2, 2004) – "Funding for Flats' watchdogs faces cuts"
Krig output map for 900-11 for contamination indicator definition at the 50 pCi/g level for Pu
903 Inner Lip Excavation Strategy and Pu contamination measurement results
903 Pad Former Drum Storage Area – two-page project summary
Conceptual Diagrams for IHHS Group 900-11 IM/IRA Alternatives
903 Lip Project Waste Data Table from RADMS for Am-241 gamma spectroscopy
903 Lip Project pictures
Information packet for the RFETS Building 444/447 Complex, February 3, 2004

Documents and Information Requested for Advisory Group

Operation and Maintenance Manual for reactive barrier systems after closure
Operation and Maintenance Manual for pond operations after closure
Criteria for O&M Manual development for post closure
Need summary of monitoring data from in/around buildings 881 and 444 for U and wells, surface water from seeps and Woman Creek
Need summary of natural uranium concentrations in concrete and sediments around buildings 444 and 881

Requests for Future Presentations and Information

Continued updates on all the issues discussed at this meeting
The Advisors would especially be interested in further information on the Legacy Management (LM) program and how the ER and LM programs will interact to provide documentation and guidance for Site operations (i e ponds, reactive barriers, maintenance roads) that span remediation and closure and extend into stewardship

Participants in AME technical meetings

Name	Organization
Chris Dayton	Kaiser-Hill
Greg Choppin	Florida State
David Clark	Los Alamos
David Janecky	Los Alamos National Laboratory
Leonard Lane	Tucson
John Stover	DOE/RFFO
Ian Paton	Wright Water Engineers
Frank Gibbs	Kaiser-Hill
Karl Shuler	Rocky Flats Closure Site Services
Cameron Freiboth	Kaiser-Hill
Victor Childress	Rocky Flats Closure Site Services
Mike Keating	Kaiser-Hill
Lane Butler	Kaiser-Hill
Gary Carnival	Kaiser-Hill
Robert Nininger	Kaiser-Hill
David Shelton	Kaiser-Hill
Scott Surovchak	DOE/RFFO
Jeff Myers	Westinghouse

Future Meetings

June 7-9, 2004
October 4-6, 2004

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